MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)

(ISO/IEC -270001 – 2005 certified)

SUMMER -2019 EXAMINATION

Subject code: 22404 **Model Answer**

Important Instructions to examiners:

1) The answer should be examined by keywords and not as word-to-word as given in the model answer scheme.

2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.

3) The language error such as grammatical, spelling errors should not be given more importance. (Not applicable for subject English and communication skill).

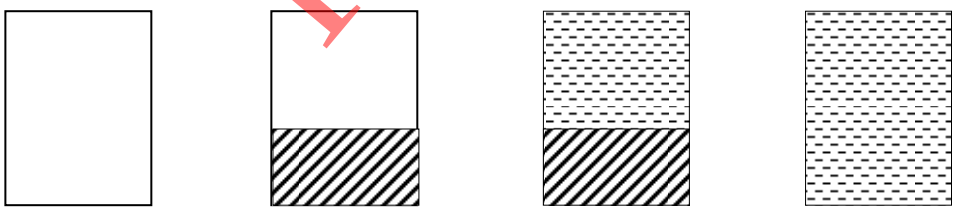
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figure drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.

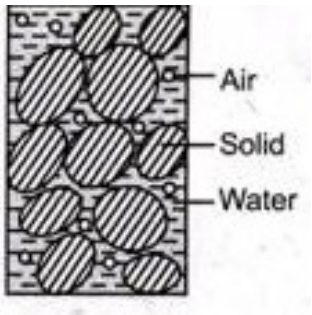
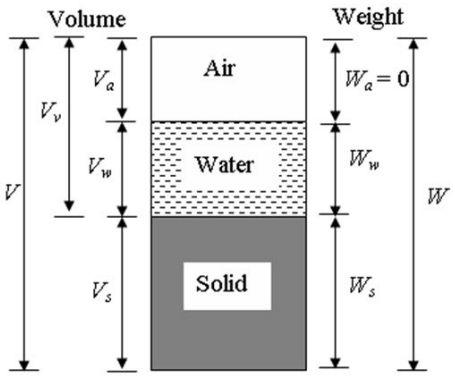
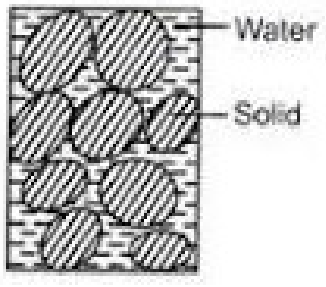
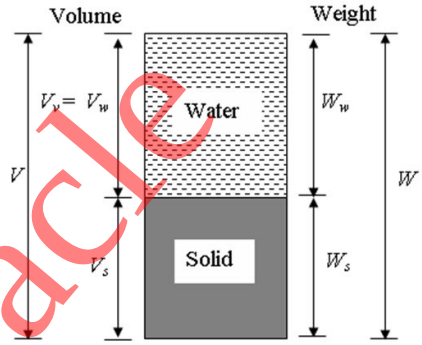
5) Credits may be given step wise for numerical problems. In the some cases, the assumed constants values may vary and there may be some difference in the candidates answer and model answer.

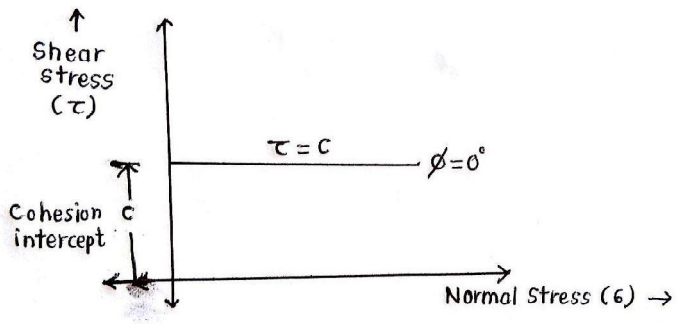
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidates understanding

Q. No.	Question and Model Answers	Marks
1.	**Attempt any FIVE of the following**	**10M**
a)	**Define Geology and state its branches.**	
	Geology : The science that deals with the study of earth as a planet as, 1. It deals with origin, age, interior or structure and history of the earth. 2. It deals with evolution and modification and extinction of various surface features. 3. It deals with material making up the earth. **Branches:** 1. Physical geology 2. Geomorphology 3. Mineralogy 4. Petrology 5. Historical geology 6. Structural geology 7. Economic geology 8. Engineering geology 9. Geo informatics.	**1 M** **1/2 M each (Any two)**

b)	**Define soil as per IS.**	
	Soil is the sediments and other unconsolidated accumulations of solid particles produced by the mechanical and chemical disintegration of rocks regardless of whether or not they contain an admixtures of organic constituent.	**2 M**
c)	**Define void ratio and bulk density.**	
	Void ratio (e) : It is ratio volume of voids (V_V)in soil to the volume of soil solids (V_S). $e = \frac{Vv}{Vs}$ Bulk density (V): It is weight of soil mass per unit volume. $\gamma = \frac{W}{V}$	**1 M** **1 M**
d)	**State any four factors affecting permeability.**	
	1. Particle size. 2. Properties of pore fluid. 3. Voids ratio. 4. Soil fabric and soil stratification. 5. Degree of saturation and foreign matter. 6. Effect of adsorbed water.	**½ each (Any four)**
e)	**Define : Cohesion and internal friction.**	
	Cohesion (C) : Cohesion is the property of soil to hold the soil particles together. It is force of attraction between same particles. **Internal friction :** The resistance to deformation by continuous shear displacement of soil particles upon action of shear stress is called internal friction.	**1 M** **1 M**
f)	**Define : Ultimate and safe bearing capacity of soil.**	
	Ultimate bearing capacity (q_u): The minimum gross pressure intensity at the base of the foundation at which the soil fails in shear. **Safe bearing capacity (q_s):** The maximum pressure which the soil can carry safely without risk of shear failure is called safe bearing capacity. $q_s = (q_{ns}) + (\gamma * D) = (\frac{q_{nf}}{F}) + (\gamma * D)$	**1 M** **1 M**
g)	**State various methods of site investigation.**	
	1. Open excavation 2. Boring 3. Sub surface soundings 4. Geophysical method.	**½ M each**

Q. 2	**Attempt any THREE of the following.**	**12**
a)	**State formation and classification of soil.**	
	Soil formation : soil formation is essentially with weathering process of rock. Soil formation mainly takes place due to mechanical disintegration or chemical decomposition of rocks whenever rock get exposed to atmosphere, It is acted by various weathering agencies and it get disintegrated or decomposed into small particles & then it is converted into soil. **Classification of Soil :** **A. Residual Soil** 1. Red Soil 2. Laterite Soil. 3. Black cotton Soil. **B. Transported Soil** 1. Colluvial Soil. 2. Alluvial Soil. 3. Glacial Soil. 4. Lacustarine Soil. 5. Eolian Soil.	**2 M** **½ M each (Any two)** **½ M each (Any two)**
b)	**Give step-by-step procedure to determine specific gravity of soil by pycnometer in laboratory.**	
	1. The mass M_1 of the clean, dry bottle is found. 2. Suitable quantity of oven-dried soil sample, cooled in a desiccator is put in the bottle and the mass M_2 of the bottle with soil is found. 3. Distilled water is then added to the soil inside bottle until the bottle is full, care being taken to see that entrapped air is fully expelled. (either by applying vacuum or by gentle heating and shaking or stirring) The mass M_3 of the bottle with soil and water is found. 4. The bottle is then emptied of its contents, cleaned and filled with distilled water only. The outer surface of the bottle is wiped dry and the mass M_4 of the bottle with water is found.  Empty bottle (Mass M_1) — With dry Soil (Mass M_2) — With Soil & Water (Mass M_3) — With Water (Mass M_4) The specific gravity of soil solids is computed as; $$G = \frac{(M_2 - M_1)}{(M_2 - M_1) - (M_3 - M_4)}$$	**3 M** **1 M**

c)	**Draw phase diagram of soil when soil is :** **(i)Moist, (ii) Fully saturated** **Label the diagrams.**	
	i) Phase diagram of moist soil :  Moist Soil mass  3 Phase system	**2 M**
	ii) Fully Saturated Soil :  Saturated Soil  2 Phase System	**2 M**
d)	**Calculate coefficient of uniformity and coefficient of curvature for a soil sample for which D_{10} = 0.430 mm, D_{30} = 0.790 mm and D_{60} = 1.300 mm.**	
	Coefficient of Uniformity = C_u $$C_u = \frac{D_{60}}{D_{10}}$$	**1 M**
	$$C_u = \frac{1.300}{0.430} = 3.02$$	**1 M**
	Coefficient of Curvature = C_c $$C_c = \frac{(D_{30})^2}{(D_{10}) \text{ X } (D_{60})}$$ $$C_c = \frac{(0.790)^2}{(0.430) \text{ X } (1.300)}$$	**1 M**
	$$C_c = 1.11$$ The Cc value is between 1 to 3, therefore soil is well graded	**1 M**

Q.3	**Attempt any THREE of the following:**	**12 M**
a)	**Explain the procedure for determination of plastic limit of soil.**	
	i. Take 20 to 25 gm. air dried soil sample passing through 425 micron IS sieve. ii. Add distilled water in soil and mix it thoroughly for 10 to 15 minutes till soil becomes plastic enough, so that it can be moldable. (It is recommended to keep clayey soils about 24 hours for its maturity.) iii. Make the balls of soil paste and roll it on non-porous glass or marble plate using figure pressure till it becomes soil thread of 3mm diameter. iv. Continue the rolling process till soil starts crumbling and it resembles a uniform thread. v. Compare the prepared soil thread with metal rod of same diameter and then stop the rolling; where soil thread crumbles into different parts. vi. Determine the water content of crumbled soil parts by oven drying method as w %. vii. Repeat all above steps two more times to get average water content as plastic limit (W_P) given soil sample	**1M each**
b)	**A soil sample is tested in constant head permeameter, dia of sample is 4 cm and length is 10 cm under constant head 15 cm discharge was found to be 70 cc in 10 mins. Find coefficient of permeability.**	
	D = 4 cm K= ? L = 10 cm H= 15 cm Q = 70 cc T = 10 min = 600 sec Solution- To find coefficient of permeability by constant head method K = Q.L/(A.h.t) Here, c/s Area of soil sample= A= Π/4 D^2 = Π/4 x 4^2 = 12.566 cm^2 K = 70 x 10/(12.566 x 15x 600) **K = 6.189 x 10^{-3} cm/sec**	**1M** **1M** **1M** **1M**
c)	**Draw shear strength envelope for purely cohesive and cohesion less soil with sketch.**	
	1. purely cohesive soil-  Fig. No. 4(a): Shear strength envelope for purely cohesive soil	**2M**

2. Cohesion less soil –

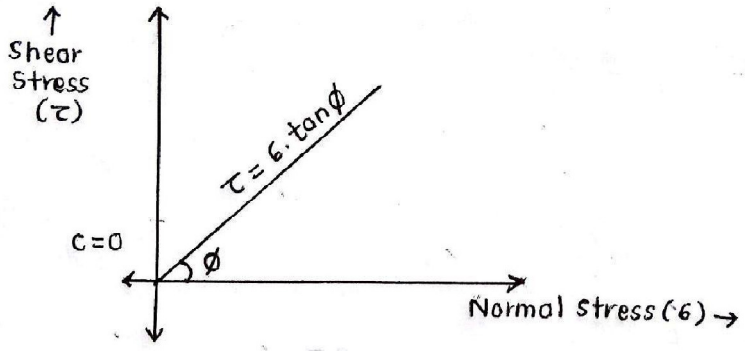


Fig. No. 4(b) : Shear strength envelope for cohesionless soil

2M

d) Differentiate between compaction and consolidation.

Sr. No	Compaction	Consolidation
1	Instant compression of soil under dynamic load is called compaction.	Gradual compression of soil under steady load is called consolidation.
2	It is fast process.	It is very slow process.
3	It is artificial process.	It is natural process.
4	It is done to improve soil properties like bearing capacity, shear strength, impermeability etc.	It takes place due to structural load which does not improve soil properties.
5	Settlement is prevented due to compaction.	Settlement takes place due tocompaction.
6	Compaction is done before construction of structure.	Consolidation takes place after construction of structure.

1M each (any four)

Q.4 Attempt any THREE of the following: **12M**

a) State characteristics of flow-net.

Characteristics of flow net are as follows:

i. The flow lines and equipotential lines in the flow net intersect each other orthogonally.

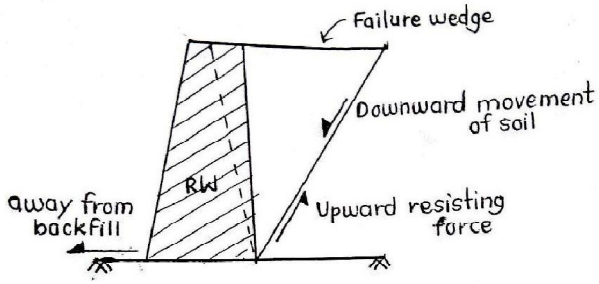
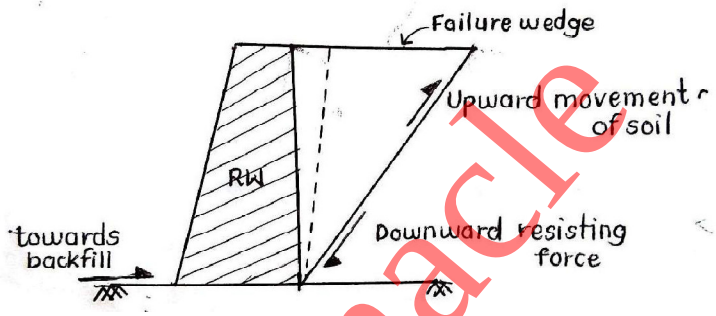
ii. The area or field formed due to intersection of these lines are approximately square.

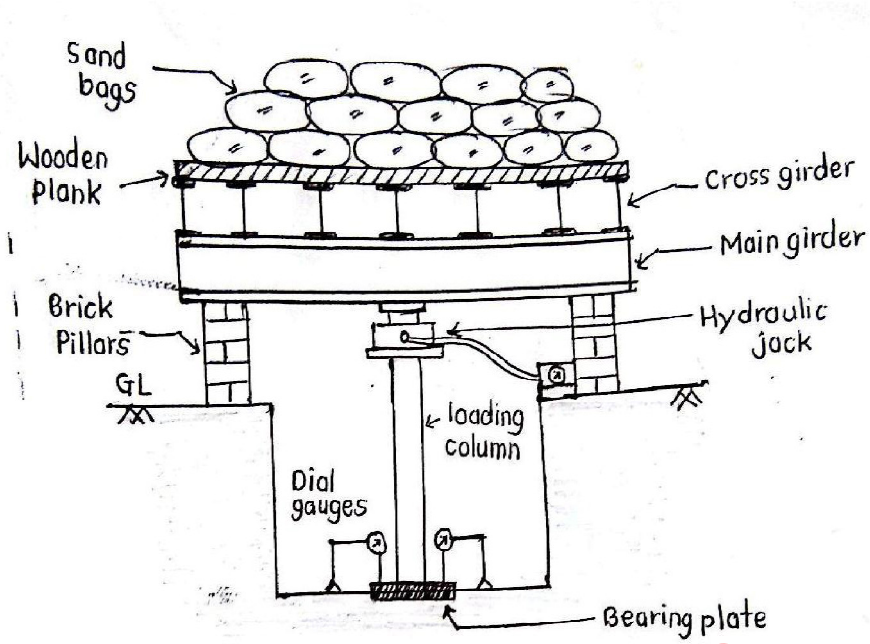
iii. The quantity of water flowing through each channel is almost same.

iv. Smaller dimensions of the field indicate greater hydraulic gradient and more velocity of flow.

v. The potential drop between two adjacent equipotential lines is same.

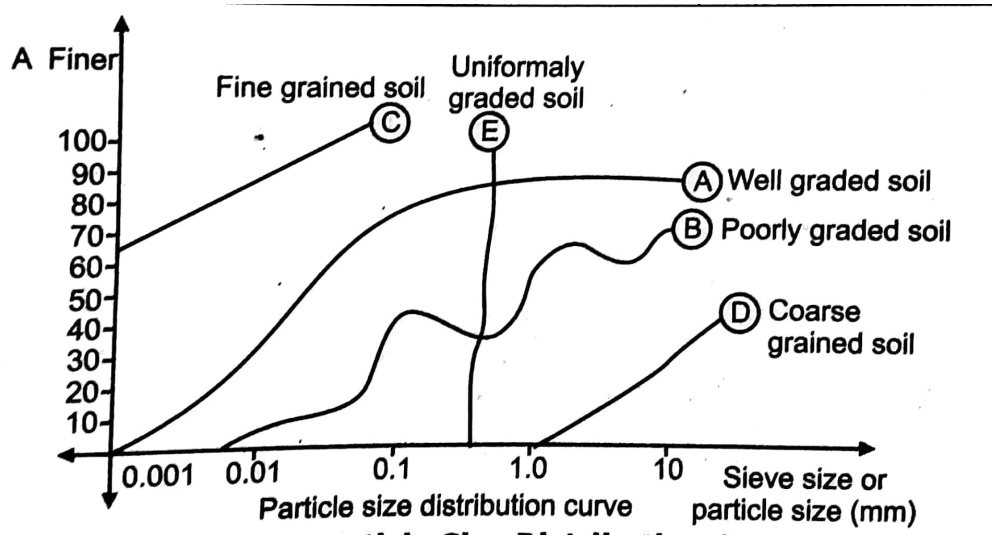
1M each (any four)

b)	**Define with sketch active and passive earth pressure.**	
	Active earth pressure: The minimum earth pressure on retaining wall which is developed due to movement of wall away from backfill is called as active earth pressure.  **Passive earth pressure:** The maximum earth pressure on retaining wall which is developed due to movement of wall towards backfill is called as passive earth pressure.  	**1M** **1M** **1M** **1M**
c)	**State any four assumptions in theory of Terzaghi's analysis of bearing capacity.**	
	Assumptions of Terzaghi's bearing capacity theory: 1. Soil behaves like ideally plastic material. 2.Soil is homogeneous , isotropic and its shear strength is represented by Coloumb's equation. 3. The total load on footing is vertical and uniformly distributed. 4. The footing is long enough with L/B = ∞ . 5.The shear strength above base of footing is neglected and taken as uniform surcharge γ Df. 6.The elastic zones developed has straight boundaries inclined at ψ =φ.	**1M each (any four)**

d)	**Draw a neat labeled sketch of plate load test set up for gravity loading.**	
	 Fig.No.8(a) : Plate Load Test	**2M sketch** **2M labelling**
e)	**Give four compaction equipments along with their seniitability.**	
	Types of Compaction Equipment: **1) Compaction by rolling:** **a) Smooth wheel rollers :** **Suitability:** These rollers best suitable for subgrade or base coarse compaction of cohesion less soils. **b) Pneumatic tyred rollers:** **Suitability:** Pneumatic tyred rollers are effective for compacting cohesive as well as cohesion less soils. Light rollers are effective for compacting soil layers of small thickness. **c) Sheep foot roller:** **Suitability:** Suitable only for fine grained soil i.e. cohesive soil **2) Compaction by Rammers:** Ramming equipments consists of three types: dropping weight type, internal combustion type and pneumatic type. Rammers or tampers are used to compact the soil of light to medium structure i.e. for plinth filling, PCC etc. **Suitability:** Suitable for all types of soil. **3) Compaction by vibratory compactors :** The vibrating equipment, mounted on screeds, plates or rollers are of two types: a) Dropping weight type and b) Pulsating hydraulic type. By giving vibration to soil, soil particles are packed together and compaction of subgrades and base course of both flexible and rigid pavement. **Suitability:** Suitable for compacting granular soils. With no fines in layer up to 1 m. **4) Compaction by Tamping:** Tamping rod is used to compact coarse grained cohesion less soils of lesser thickness.	**1M each (½ M name and ½ M suitability) (any four)**

Q.5	**Attempt any TWO of the following.**	**12 M**
(a)	**Explain the various field application of geotechnical engineering in details.**	
	The field of geotechnical engineering includes some of the important applications as: a) Foundation design b) Pavement Design c) Design of earth retaining structures d) Design of earthen dams e) Design of embankments f) Underground structures. **a) Foundation design-**Every civil engineering structure like a building, bridge, highway, or a dam lies in or on the surface of earth. Foundation is required is required to transmit the load of structure to soil safely and efficiently. Therefore bearing capacity of soil and knowledge of stress distribution below the loaded area, settlement of foundation, effect of vibration, effect of ground water etc. is essential to known. b) **Pavement Design:** A pavement is a hard crust placed on soil (subgrade) for the purpose of providing a smooth and strong surface on which vehicles can move. Pavement is of two types either flexible or rigid. Thickness of pavement depends upon subsoil and its component parts. It also depends upon the effect of repetition of loading intensity of traffic, construction materials, earth fills or cut etc. c) **Design of earth retaining structures:** When sufficient space is not available for a mass of soil to spread and form a slope, a structure is required to retain the soil. an earth retaining structure is also required to keep the soil at different levels on its either sides. The knowledge of active earth pressure, passive earth pressure, density and moisture content is essential for design of earth retaining structures. d) **Design of earthen dam:** In construction of earthen dam, soil is main constituent which may be homogeneous and heterogeneous. Therefore, its design requires thorough knowledge of index properties, plasticity characteristics, particle size distribution, specific gravity, permeability, consolidation, compaction and shear strength. since failure of an earthen dam may cause widespread catastrophe, extreme care is taken its design and construction. **e) Design of Embankment:** Due to up and downs in earth surface, stability of structure may disturb. So for stable design of slopes of filling and cutting, the knowledge of shearing strength, angle of repose and frictional coefficient is essential for the design of slopes in embankment or in cutting etc. **f) Underground Structures and miscellaneous:** design and construction of underground structure such as pipe lines, tunnels, underground buildings etc. requires the knowledge of density of soil, consolidation of soil, bearing capacity of soil and water condition of sub soil strata is essential.	**2M** **4M for any Four Explai nation**

(b)	**Draw particle size distribution curve. Explain mechanical sieve analysis for grading of soil with sketch.**	



Particle size distribution curve

2M for Graph

Mechanical sieve analysis: The process of analyzing the particle size present in soil by using mechanical means is known as mechanical sieve analysis. By performing mechanical sieve analysis, a particle size distribution curve is plotted for grading of soil.

Procedure:

i) Initially keep the given soil sample in rapid moisture meter for 2-3 hours to get oven dried soil. Break the visible lumps present in soil using fingers with light pressure.

ii) Arrange the set of I.S. sieves in descending order i.e. coarser sieve at top and finer sieve at bottom. The IS sieve set must include sieves of size 4.75mm, 2.36mm, 1.18mm, 600mic., 300 mic, 150 mic, 75 and pan.

iii) Take the soil sample about 500-1000gm and put it on topmost sieve. Keep lid and pan at top and bottom respectively.

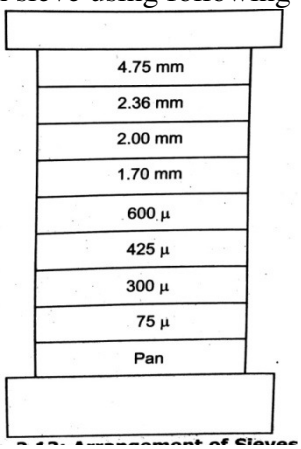
iv) Now, shake this assembly of sieve on mechanical sieve shaker for 10-15 minutes, so that soil sample will be sieved completely.

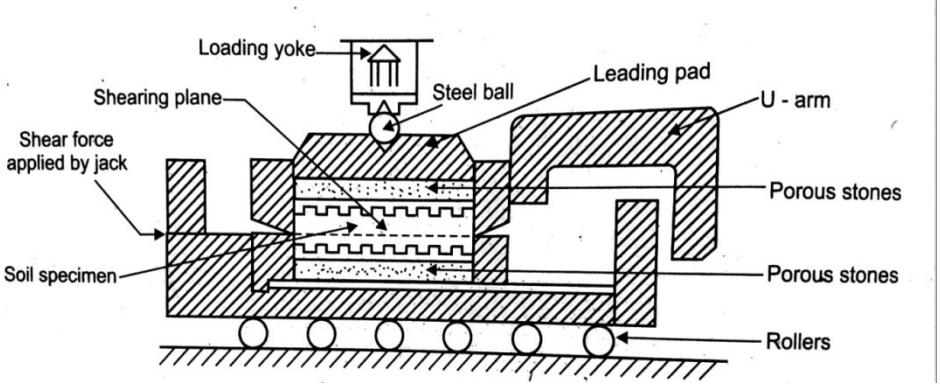
4M for Procedure And sketch

Seive size	Mass Retained (gm)	Cumulative mass retained (gm)	%Cumulative mass retained	%Finer Passing

v) Take the weight of soil mass retained on each sieve separately in grams.

vi) Calculate % finer for each sieve using following tabular format.



.(c)	**Explain the direct shear test to determine shear strength of soil with neat sketch.**	
	Procedure: 1. Take 2.5 kg air dried soil sample passing through 4.75mm and retained on 2.36mm IS sieve and measure the internal dimensions of of shear box. Also determine the average thickness of the grid plates. 2. Fix the upper part of the box to the lower part using locking screws. Attach the base plate to the lower part. 3. For performing a UU test, plain toothed grids (without perforations) are used at the top and bottom faces of samples. Shear force is applied immediately after applying the normal load. Place the grid plate in the shear box keeping the serrations of the grid at right angles to the direction of shear. Place the porous stone over the grid plate. 4. Weigh the shear box with base plate, grid plate and porous stone. Place the soil specimen in the box. Tamp it directly in the shear box at the required density. 5. When the soil in the top half of the shear box is filled weigh the box with soil specimen and fix the loading pad on the box. Mount the box contained on the loading frame. 6. Bring the upper half of the box in contact with the proving ring. Check the contact by giving a slight movement. Fill the container with water if the soil is to be saturated. 7. Mount the loading yoke on the ball placed on the loading pad. Mount the dial gauge on the loading yoke to record the vertical displacement and another dial gauge on the container to record the horizontal displacement. 8. Place the weights on the loading yoke to apply a normal stress. Allow the sample to consolidate under the applied normal stress. Note the reading of the vertical displacement dial gauge. 9. Remove the locking screws using the spacing screws, raise the upper part slightly above the lower part such that the gap is slightly larger than the maximum particle size. Remove the spacing screws and adjust all the dial gauges to read zero. The proving ring should also read zero. 10. Apply the horizontal shear load at a constant rate of strain of 0.2mm/minute. Record the reading of proving ring, the vertical displacement dial gauge and horizontal displacement dial gauge at regular time intervals. Take few readings at closer intervals. 11. Continue the test till the specimen fails or till a strain of 20% is reached. At the end of the test, remove specimen from the box and take a representative sample for water content determination. 12. Repeat the test on identical specimens under the normal stresses of 50, 100, 200, 400, KN/m. plot the graph by taking the values of Normal stress as abscissa and the maximum shearing stress as ordinate.  **Direct shear test Arrangement**	**4M for Procedure** **2M for sketch**

Q.6	Attempt Any TWO of the following	12 M

a) Following observations were made using standard proctor test on a soil sample:

Bulk density gm/cc	1.75	1.95	2.10	2.20	2.15	2.05
Water content (%)	5	10	15	20	25	30

Determine OMC and MDD by plotting compaction curve on graph.

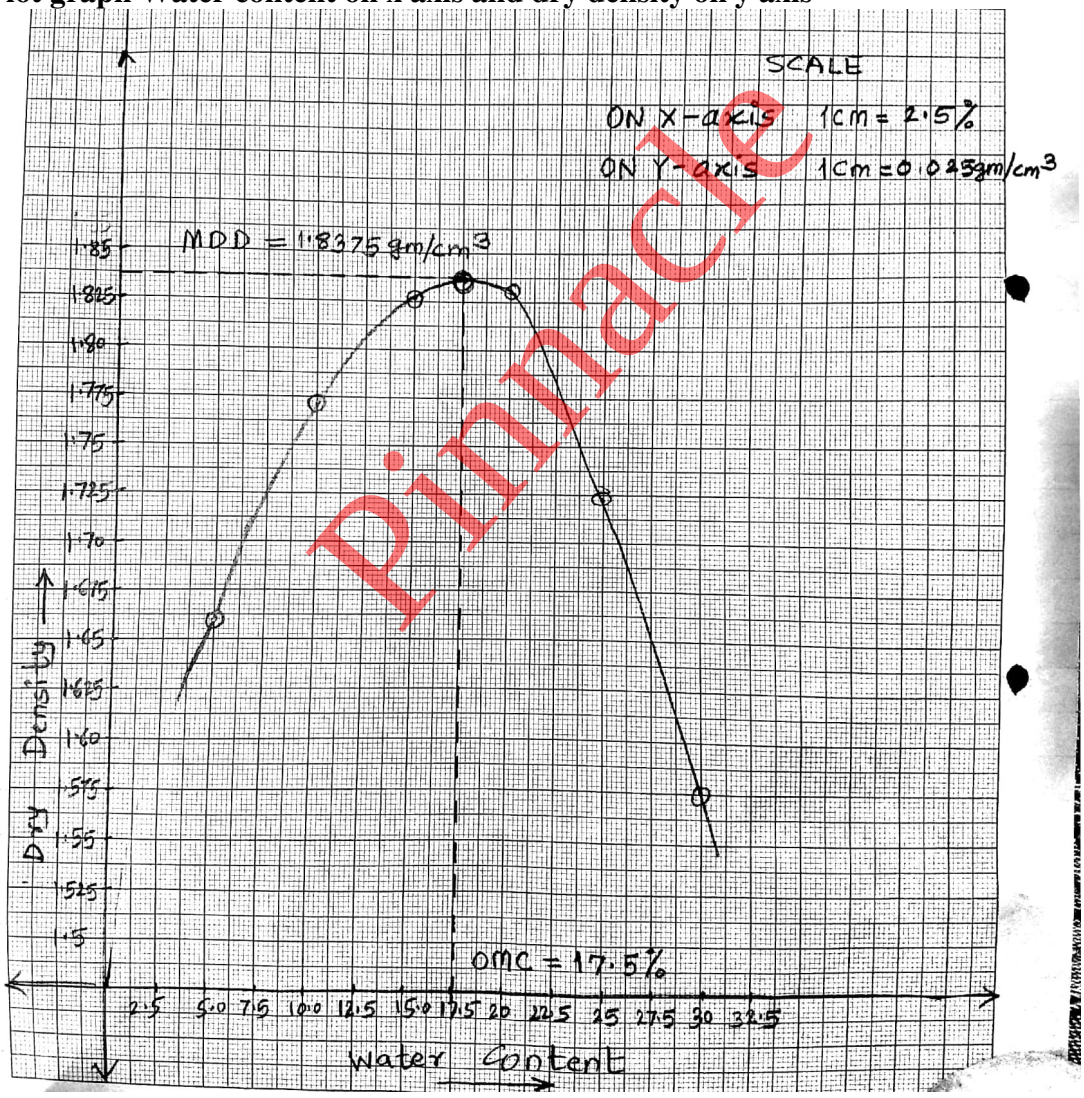
Calculate dry density for each reading as

Dry density $\gamma_d = \frac{\gamma}{1+w} = \frac{1.75}{1+0.05} = 1.666 \text{ gm/cm}^3$

Bulk density gm/cc	1.75	1.95	2.10	2.20	2.15	2.05
Water content (%)	5	10	15	20	25	30
Dry density gm/cc	1.666	1.772	1.826	1.833	1.72	1.576

2M

Plot graph Water content on x axis and dry density on y axis



4M for Graph And result

Optimum Moisture Content by Graph = 17.5%
Maximum Dry Density by Graph = 1.8375 gm/cm^3

b)	**State the methods of soil stabilization. Explain any one.**	
	1) Mechanical Stabilization 2) Cement Stabilization 4) Chemical stabilization 4) Bitumen stabilization 5) Stabilization by heating 6) Electrical stabilization 7) Fly ash stabilization 8) Lime stabilization **1) Mechanical Stabilization:** In this method, stabilization of soil is done without adding any chemicals or admixtures. The procedure of mechanical stabilization is described below. i) Initially soil is excavated using excavator and then it is ground to finer particles using pulveriser. ii) In this pulverized soil, well graded aggregates are spread and mixed till homogeneous mixture will form. iii) Then water is sprinkled upto a optimum moisture content i.e. OMC for getting maximum dry density i.e. MDD. iv) The heavy roller (8-10 tonne capacity) is used to compact soil 15-20 cm thickness as per type of soil available. v) The compacted surface is cured by sprinkling water on it, followed by compaction. The curing and compaction is done alternatively for 7 days. Then the stabilized portion is allowed for its further use. **OR** **2) Cement Stabilization:** The soil is stabilized with Portland cement is known as soil cement and the process is known as Cement stabilization. The stabilization takes place due to the cementing action believed to be the result of chemical action of cement with soil containing silicon during hydration. 5 to 15% cement is added to increase the strength, the strength of soil cement increases with increase in cement content. A stronger and durable soil cement will be produced, if the soil cement water mixture is mixed properly. The normal construction procedure for soil cement bases is as follows: i) shaping the sub grade and scarifying the soil. ii) Pulverising the soil iii) Adding and mixing cement iv) Adding and mixing water v) compacting vi) Finishing vii) Curing viii) Adding wearing surface. **(Note: Explanation of any one or other method from above should be considered.)**	**2M** **4M (for any one)**
c)	**State field identification test on soil and explain any one.**	
	Following are the field identification tests on soil 1. Visual examination 2. Dilatency test 3. Toughness 4. Dry strength 5. Organic and colour 6. Other identification tests **1. Visual Examination:** The visual examination is carried out by eyes only after taking a representative sample of soil and spreading it on a flat surface on plam of the hand. The visual examination is carried out with respect to size, angularity, touch and grading. **2. Dilatency:** This is also a simple test used in field for rough classification of soil. i) A 5cm^3 of soil sample is taken and enough water is added to nearly saturate it. The	**2M** **4M for Any one method**

	part of soil is placed in the open palm of the hand and shaken horizontally, striking rigorously against the other hand several times. ii) The pat is then squeezed between the fingers. The appearance and disappearance of water with shaking and squeezing is referred to as a positive reaction. iii) The reaction is called quick, if water appears and disappears rapidly. It is called slow, if water appears and disappears slowly and no reaction if water does not appear. iv) The type of reaction is observed and recorded. Inorganic soils exhibits a quick reaction whereas clays exhibit none to slow. **3. Dry strength test:** i) The prepared soil sample is completely dried in the sun or by air drying. Its strength is tested by breaking between fingers. ii) Dry strength or resistance to breaking, is a measure of plasticity and is considerably induced by the colloidal fraction content of the soil. iii) If the dry sample can be easily powered, it is said to have low dry strength, whereas, if considerable finger pressure is required to break the lump, it is said to have a medium dry strength and if it cannot be powered at all, it is said to have high dry strength. iv) Dry strength is characteristic of clays of high plasticity. Typical inorganic silts have only a slight dry strength. silty fine sands and silts have practically the same low strength but can be distinguished from each other by their feel during powdering of the dry sample. **(Note: Explanation of any one or other method from above should be considered.)**	